PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2001-117005
(43)Date of publication of application : 27.04.2001

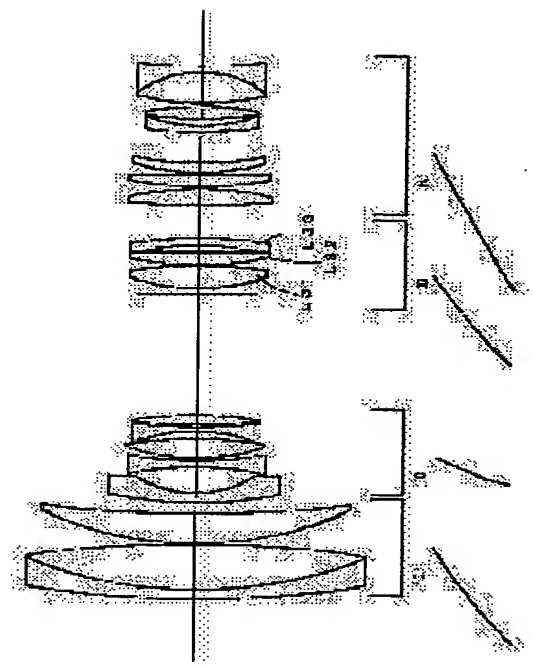
(51)Int.Cl. G02B 15/20
G02B 13/18

(21)Application number : 11-294823
(22)Date of filing : 18.10.1999

(71)Applicant : SIGMA CORP
(72)Inventor : KUSAKAWA TETSUSUKE

(54) HIGH VARIABLE POWER ZOOM LENS

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain a compact high variable power zoom lens restraining the moving amount of a 1st group to be small, including a wide-angle area, having a zoom ratio being about 10 and having high performance in a zoom system where four groups are moved without increasing the number of moving groups.
SOLUTION: This zoom lens is constituted of a 1st lens group having positive power, a 2nd lens group having negative power, a 3rd lens group having positive power and a 4th lens group having positive power in order from an object side. In the case of varying power from a wide angle end to a telephoto end, the 1st, the 3rd and the 4th groups are moved in an object direction while a distance between the 1st and the 2nd lens groups is increased and a distance between the 2nd and the 3rd lens groups is decreased, and focusing is performed by extending the 2nd lens group and a fixed condition is satisfied.



LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] Negative and the 3rd lens group in order [side / body] Forward, [the 1st lens group] [forward and the 2nd lens group] The 4th lens group consisting of four lens groups with forward refractive power, making air spacing of the above-mentioned 1st lens group and the 2nd lens group expand on the occasion of the variable power from a wide angle edge to a tele edge, and making spacing of the 2nd lens group and the 3rd lens group reduce in the first half It is the rate zoom lens of high variable power which the 1st, 3rd, and 4th lens group moves in the direction of a body, and is characterized by focusing satisfying delivery ****** and the following conditional expression for the 2nd lens group.
(1) Focal distance 4D of the focal distance f4:4th lens group of the focal distance f3:3rd lens group of the focal distance f2:2nd lens group of $6.0<f1/|f2|<7.0$(2)$1.7<f1/f3<1.9$(3)$1.8<f1/f4<2.2$(4) $0.45<4\ D/f\ 4<0.65$, however the f1:1st lens group : it is the lens overall length of the 4th lens group.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the rate zoom lens of high variable power with which the zoom ratio used for an one eye reflex camera, a video camera, etc. exceeds 10 times.
[0002]
[Description of the Prior Art] If it is going to make into high performance the rate zoom lens of high variable power on which a wide angle edge begins from 28mm with the photographic lens for 35mm, a system tends to become large-sized and the movement magnitude of the 1st group tends to become large.
[0003] The optical system from which it is indicated by JP,3-83005,A, concerning the 10 time zoom system by which a wide edge begins from 28mm consists of five groups which have forward, negative, forward, forward, and negative refractive power sequentially from a body side. By considering forward, negative, forward, and forward 4 group zoom as a basic configuration, with the configuration which added the fixed group of transpiration to the backmost part, since the power of the 2nd group is weak, the zoom lens of this 5 group configuration has the large movement magnitude of each group, and it has the trouble said that the lens overall length of a wide edge is long.
[0004] Moreover, similarly JP,10-133109,A of the zoom method with which five groups which have forward, negative, forward, negative, and forward refractive power move has not conquered the trouble that the lens overall length of a wide edge is long, and the movement magnitude of the 1st group is large, with JP,3-83005,A sequentially from a body side.
[0005]
[Problem(s) to be Solved by the Invention] This invention is the zoom method which four groups move, without increasing the number of migration groups, and is in implementation of the compact rate zoom lens of high variable power with about ten zoom ratio [in which the movement magnitude of the 1st group includes a small wide angle region] high performance.
[0006]
[Means for Solving the Problem] This invention unified and solved the conflict which will be said that the aberration fluctuation by the manufacture error becomes large at a tele edge if it is made a compact at a problem inevitable to the design of the rate zoom lens of high variable power, i.e., a wide edge, by giving the following configuration and conditions on the basis of the basic thought of design of constituting the power of each group as weakly as possible.
[0007] Namely, the 1st lens group of power more nearly forward than a body side to order, the 2nd lens group of negative power, Consist of a 3rd lens group of forward power, and a 4th lens group of forward power, and air spacing of the 1st lens group and the 2nd lens group increases on the occasion of the variable power of looking far from a wide angle. While air spacing of the 2nd lens group and the 3rd lens group decreases, each group of the 1st, and 3 and 4 moves in the direction of a body. focusing — the delivery of the 2nd lens group — carrying out — (1) — 6.0<f1/|f2| — < — 7.0(2)1.7<f1/f3 — < — 1.9(3)1.8<f1/f4 — < — it is the system characterized by satisfying the conditional expression of 2.2(4)0.45<4 D/f 4< 0.65. However, f1, f2, f3, and f4 are the focal distances of the 1st, 2, 3, and 4 group, and 4D expresses the lens overall length of

the 4th group.
[0008]
[Function] Conditional expression (1) Although − (3) specifies the relation of the power of each group, it can realize a rate zoom of high variable power with the small movement magnitude of the 1st group relatively to a lens overall length by this. Although it is advantageous to a raise in a scale factor if the upper limit of conditional expression (1) is exceeded, enlargement of a system is caused and the movement magnitude of the 1st group increases. To a lens overall length, if the movement magnitude of the 1st group is relatively large, bending of a lens-barrel will arise, and it is not desirable structural. Conversely, if the power of the 1st group becomes strong exceeding a minimum, rate-ization of high variable power will become difficult, and it will be hard coming to realize high performance-ization in a wide edge.
[0009] They are the conditions it is [conditions] indispensable to rate-ization of high variable power, conditional expression (2) maintaining high performance. It is easy to make it high variable power so that the subsystem from the 1st group to the 3rd group forms the near condition afocal and the upper limit of conditional expression (2) is exceeded, but the problem which carries out opposite side enlargement follows, and since the power of the 3rd group becomes strong, spherical aberration tends [further] to become the lack of amendment. Conversely, if a minimum is exceeded, although it is advantageous to amendment of spherical aberration, rate[of high variable power]-izing is difficult. This invention solved the problem that amendment of spherical aberration was insufficient, by making the field of the 3rd group into the aspheric surface further, was highly efficient and made rate-ization of high variable power easy.
[0010] Conditional expression (3) is conditions required since the possibility of good aberration amendment is guaranteed and a system is constituted in a compact. Although it is so good for the power of the 4th group becoming strong and miniaturizing that an upper limit is exceeded, the situation where back focuses run short in a wide edge will arise. Moreover, if the power of the 4th group becomes strong, the performance degradation of a wide periphery will become remarkable especially. Conversely, if a minimum is exceeded, the power of the 4th group will become weak, and although axial extraversio ability is made good, since a system enlarges it, it is not desirable.
[0011] The conditions of conditional expression (4) are for conditional expression (3) and an interval to make axial extraversio ability good. Although the 4th group carries out image formation of the virtual image which the subsystem to three groups forms to a real image, the image formation scale factor takes the value of a up to [from a contraction scale factor] near the actual size, and its scale-factor fluctuation is the largest of the four groups. Moreover, there are particulars to which it is behind a diaphragm and an axial outdoor daylight bundle passes through the periphery of the 4th group lens. It is effective in aberration amendment to constitute each side of the 4th group from biggest possible radius of curvature to these particulars. The lens overall length was also enlarged and this invention enlarged the radius of curvature of each field for it while making [many] the configuration number of sheets of the 4th group. However, although it is good for aberration amendment when exceeding an upper limit, since a system is enlarged, when exceeding a minimum conversely preferably, effectiveness of sufficient aberration amendment cannot be acquired.
[0012]
[Example] The numerical example 1 of the rate zoom lens of high variable power of this invention, the numerical example 2, and the numerical example 3 are shown below.
[0013] Drawing 1 is [the lens sectional view of the numerical example 2 and drawing 3 of the lens sectional view of the numerical example 1 and drawing 2] the lens sectional views of the numerical example 3. I in drawing 1 thru/or drawing 3 is the 1st lens group of forward refractive power, the 2nd lens group of refractive power negative in II., the 3rd lens group of refractive power forward in III, and the 4th lens group of refractive power forward in IV. The lens of the aspheric surface and L32 are constituted by the positive lens of both the convexes in the 3rd lens group III, and, as for L31, a front face is constituted from both the convexes in the 3rd lens group III by the negative lens in the 3rd lens group III, as for L33. The aberration Fig. of the wide angle edge of the numerical example 1 of this invention and drawing 5 drawing 4 The aberration

Fig. of the middle region of the numerical example 1 of this invention, The aberration Fig. of the tele edge of the numerical example 1 of this invention and drawing 7 drawing 6 The aberration Fig. of the wide angle edge of the numerical example 2 of this invention, For the aberration Fig. of the middle region of the numerical example 2 of this invention, and drawing 9 , the aberration Fig. of the tele edge of the numerical example 2 of this invention and drawing 10 are [drawing 8 / the aberration Fig. of the middle region of the numerical example 3 of this invention and drawing 12 of the aberration Fig. of the wide angle edge of the numerical example 3 of this invention and drawing 11] the aberration Figs. of the tele edge of the numerical example 3 of this invention.

[0014] It realized performing aberration amendment good, without lengthening and using the aspheric surface for this group as it comes out of the focal distance of the 2nd lens group like the above-mentioned and comes by this example, making manufacture of the 2nd lens group easy, and making the aberration coefficient of the whole system small.

[0015] the numerical example 1 thru/or 3 — setting — f — a focal distance and Fno — the f number and omega — a half-field angle — it is — ri — a body side — order — the i-th lens thickness and air spacing, and ni and vi of the radius of curvature of the i-th lens side and di are the i-th lens refractive index and the Abbe number in order from an each body side in a body side. An aspheric surface configuration is expressed with the following formulas when it is made into the y-axis to a x axis, an optical axis, and a perpendicular direction in the direction of an optical axis.

1+{1-A(y2/r2)}1 / x= (y2/r) / [2]+A4y4+A6y6+A8y8+A10y10, however r are [an aspheric surface multiplier and A of paraxial radius of curvature, A4, and A6, A8 and A10] constants of the cone.

[0016] Numerical example 1f=29.01-99.2-289.17Fno=3.58-5.66-6.54omega=38.1 degree-11.7 degree-4.1 degree[0017]

ri di ni Vi [1] 144.28 1.85 1.8061 33.3 [2] 69.49 8.32 1.4970 79.3 [3] -228.42 0.15 [4] 56.88 5.49 1.4875 70.2 [5] 193.34 Good [6] 6 [strange] 77.86 1.32 1.8340 37.3 [7] 16.34 5.34 [8] -36.17 1.05 1.7725 49.7 [9] 74.16 0.15 [10] 34.05 3.74 1.8467 23.9 [11] -76.36 1.20 [12] -26.160.90 1.7725 49.7 [13] 125.48 0.15 [14] 222.21 1.80 — 1.846723.9 [15] -87.65 Good [16] strange 16 0.00 1.00 [17] 31.46 0.10 1.5184 52.1 [18] 33.26 4.14 1.487570.2 [19] -86.55 0.15 [20] 53.20 2.521.4875 70.2 [21] -197.79 1.29 [22] -34.52 0.90 1.8052 25.5 [23] -126.13 Good Strange [24] 126.653.05 1.4875 70.2 [25] -44.45 0.15 [26] 51.44 2.40 1.4875 70.2 [27] -641.17 0.15 [28] 33.82 2.07 1.4875 70.2 [29] 71.50 5.75 [30] 80.09 0.90 1.8042 46.5 [31] 21.13 1.42 [32] 215.93 1.99 1.4875 70.2 [33] -51.94 0.61 [34] 40.32 6.09 1.5481 45.9 [35] -15.16 0.90 1.772549.7 [36] 115.48 [0018]

* Aspheric surface r17A 0.19672000D+01 A4 -0.96281563D-05A6 0.11861471D-08A8 - 0.37909715D-10A10 0.12170679D-12[0019]

Focal distance 29.01 99.2 289.17 d (5) 2.30 36.80 63.05 d (15) 22.53 10.80 1.00 d (23) 6.45 1.35 0.45 [0020] Conditional-expression (1) f1/|f2|=6.58(2) f1/f3=1.81(3) f1/f4=1.99(4) 4 D/f 4= 0.48

[0021] Numerical example 2f=28.9-99.2-289.97Fno=3.54-5.61-6.55omega=38.2 degree-11.7 degree-4.1 degree[0022]

ri di ni Vi [1] 137.39 1.85 1.8061 33.3 [2] 68.33 8.59 1.4970 79.3 [3] -196.36 0.15 [4] 55.68 5.00 1.4875 70.2 [5] 147.58 Good [6] 6 [strange] 81.02 1.30 1.8340 37.3 [7] 16.48 5.13 [8] -33.79 1.05 1.7725 49.7 [9] 85.65 0.15 [10] 35.00 3.60 1.8467 23.9 [11] -69.20 1.13 [12] -26.510.90 1.7725 49.7 [13] 129.66 0.15 [14] 322.55 1.85 — 1.846723.9 [15] -82.28 Good [16] strange 16 0.00 1.00 [17] 31.46 0.10 1.5184 52.1 [18] 33.26 4.06 1.487570.2 [19] -84.04 0.15 [20] 55.47 2.391.4875 70.2 [21] -249.65 1.39 [22] -33.31 0.90 1.8052 25.5 [23] -122.75 Good Strange [24] 120.093.05 1.4875 70.2 [25] -45.53 0.15 [26] 55.71 2.40 1.4875 70.2 [27] -353.84 0.15 [28] 36.02 2.06 1.4875 70.2 [29] 82.08 6.38 [30] 61.53 0.90 1.8042 46.5 [31] 20.89 1.37 [32] 145.69 1.97 1.4875 70.2 [33] -59.75 0.39 [34] 41.70 5.92 1.5442 45.4 [35] -15.21 0.90 1.772549.7 [36] 115.48 [0023]

* Aspheric surface r17A 0.19672000D+01 A4 -0.89413878D-05A6 0.15270304D-10A8 - 0.45518891D-10A10 0.25002753D-12[0024]

Focal distance 28.9 99.2 289.97 d (5) 2.25 36.96 62.98 d (15) 22.73 10.81 0.80 d (23) 6.54 1.51 0.45 [0025] Conditional expression (1) f1/|f2|=6.53 (2) f1/f3=1.71 (3) f1/f4=2.13 (4) 4 D/f 4= 0.51

[0026] Numerical example 3f=29.02-99.2-289.13Fno=3.58-5.65-6.56omega=38.1 degree-11.7 degree-4.1 degree[0027]
ri di ni Vi [1] 144.15 1.85 1.8061 33.3 [2] 69.53 8.21 1.4970 79.3 [3] -228.36 0.15 [4] 56.88 5.48 1.4875 70.2 [5] 190.91 Good [6] 6 [strange] 77.12 1.32 1.8340 37.3 [7] 16.33 5.30 [8] -35.93 1.04 1.7725 49.7 [9] 72.99 0.15 [10] 34.26 3.56 1.8467 23.9 [11] -75.29 1.20 [12] -26.110.90 1.7725 49.7 [13] 138.97 0.15 [14] 267.08 1.80 — 1.846723.9 [15] -82.81 Good [16] strange 16 0.00 1.00 [17] 31.46 0.10 1.5184 52.1 [18] 33.26 4.09 1.487570.2 [19] -81.00 0.15 [20] 54.50 2.441.4875 70.2 [21] -224.51 1.35 [22] -33.58 0.90 1.8052 25.5 [23] -117.98 Good Strange [24] 152.963.05 1.4875 70.2 [25] -41.86 0.15 [26] 49.68 2.40 1.4875 70.2 [27] -1866.37 0.15 [28] 34.361.98 1.4875 70.2 [29] 67.58 6.05 [30] 71.39 0.90 1.8042 46.5 [31] 21.34 1.38 [32] 156.28 1.99 1.4875 70.2 [33] -56.70 0.57 [34] 41.82 6.03 1.5481 45.9 [35] -15.13 0.90 1.7725 49.7 [36] 115.48 [0028]
* Aspheric surface r17A 0.19672000D+01 A4 -0.92247643D-05A6 0.11861471D-08A8 -0.37909715D-10A10 0.12170679D-12[0029]
Focal distance 29.02 99.2 289.17 d (5) 2.3 36.91 63.11 d (15) 22.76 10.90 1.00 d (23) 6.54 1.44 0.45 [0030] Conditional-expression (1) f1/|f2|=6.56(2) f1/f3=1.81(3) f1/f4=1.99(4) 4 D/f 4= 0.48 [0031]
[Effect of the Invention] According to this invention, a lens with little aberration fluctuation by the manufacture error is realizable by limiting power and the movement magnitude direction in 4 group zoom lens group which has forward, negative, forward, and forward refractive power in order from a body side as mentioned above, being with the rate zoom lens of high variable power including a wide angle region.

[Translation done.]

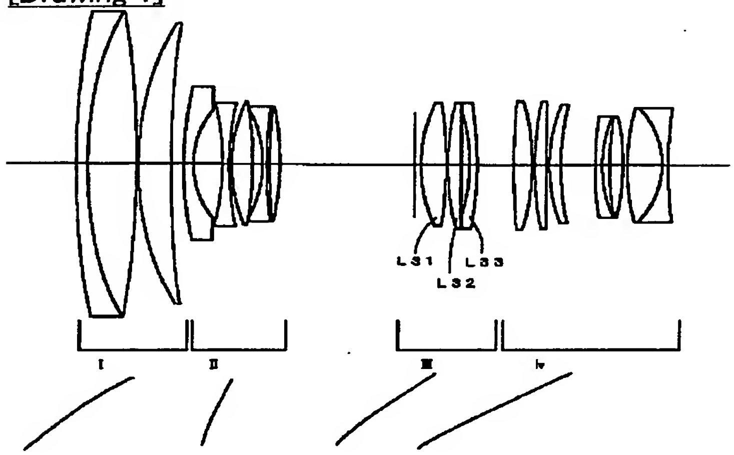
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the lens sectional view of the numerical example 1 of this invention.
[Drawing 2] It is the lens sectional view of the numerical example 2 of this invention.
[Drawing 3] It is the lens sectional view of the numerical example 3 of this invention.
[Drawing 4] It is the aberration Fig. of the wide angle edge of the numerical example 1 of this invention.
[Drawing 5] It is the aberration Fig. of the middle region of the numerical example 1 of this invention.
[Drawing 6] It is the aberration Fig. of the tele edge of the numerical example 1 of this invention.
[Drawing 7] It is the aberration Fig. of the wide angle edge of the numerical example 2 of this invention.
[Drawing 8] It is the aberration Fig. of the middle region of the numerical example 2 of this invention.
[Drawing 9] It is the aberration Fig. of the tele edge of the numerical example 2 of this invention.
[Drawing 10] It is the aberration Fig. of the wide angle edge of the numerical example 3 of this invention.
[Drawing 11] It is the aberration Fig. of the middle region of the numerical example 3 of this invention.
[Drawing 12] It is the aberration Fig. of the tele edge of the numerical example 3 of this invention.
[Description of Notations]
I The 1st lens group of forward refractive power
II The 2nd lens group of negative refractive power
III The 3rd lens group of forward refractive power
IV The 4th lens group of forward refractive power

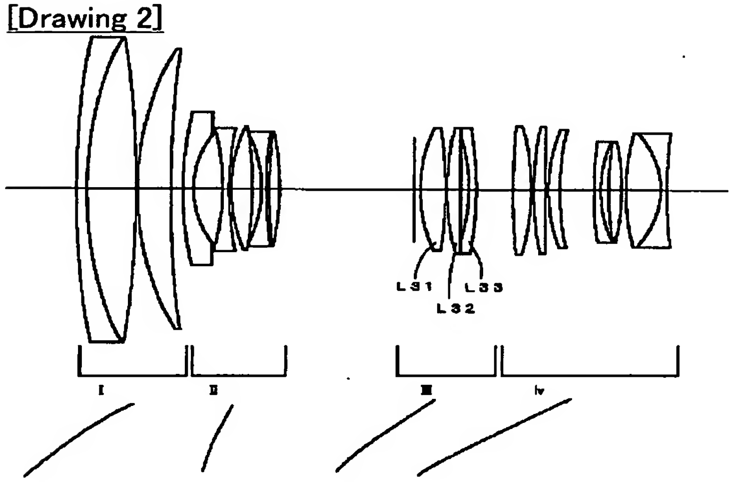
[Translation done.]

DRAWINGS

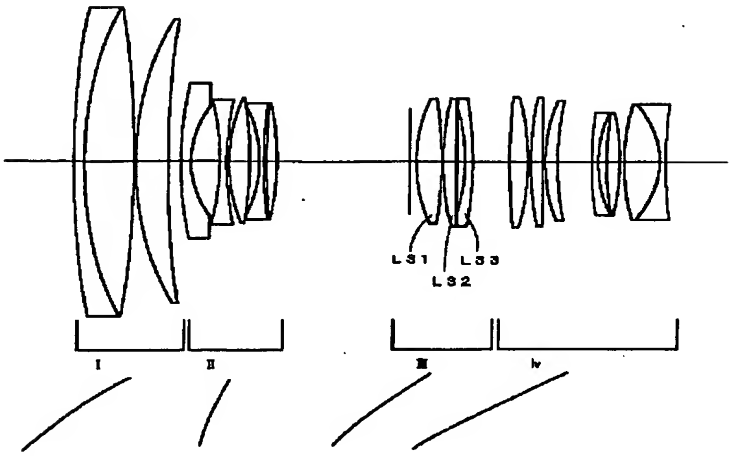
[Drawing 1]



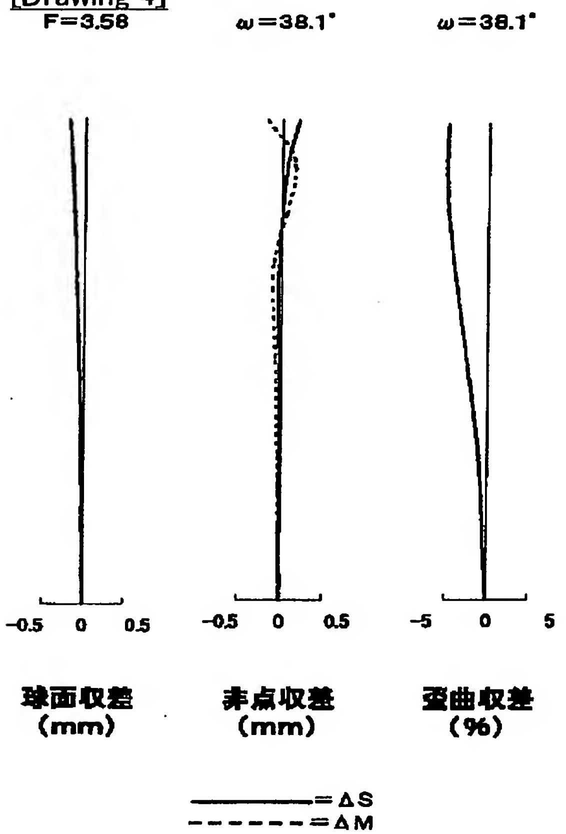
[Drawing 2]



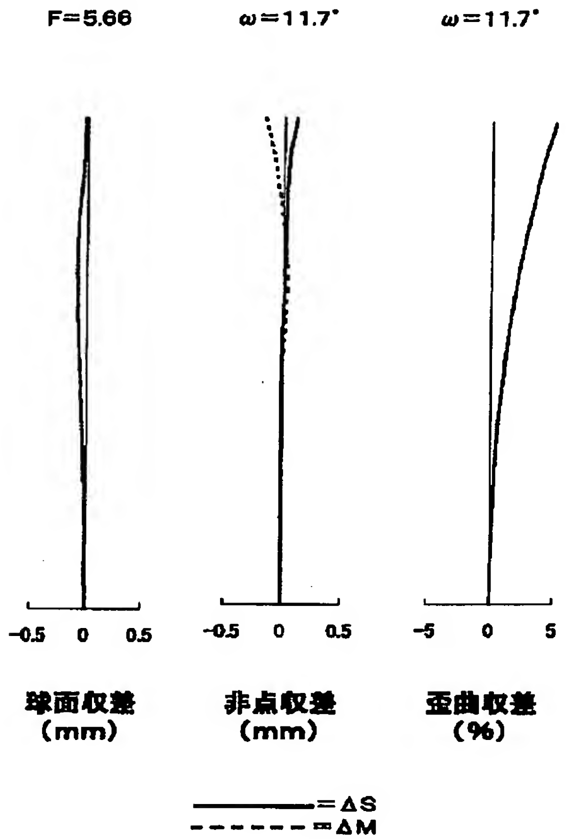
[Drawing 3]



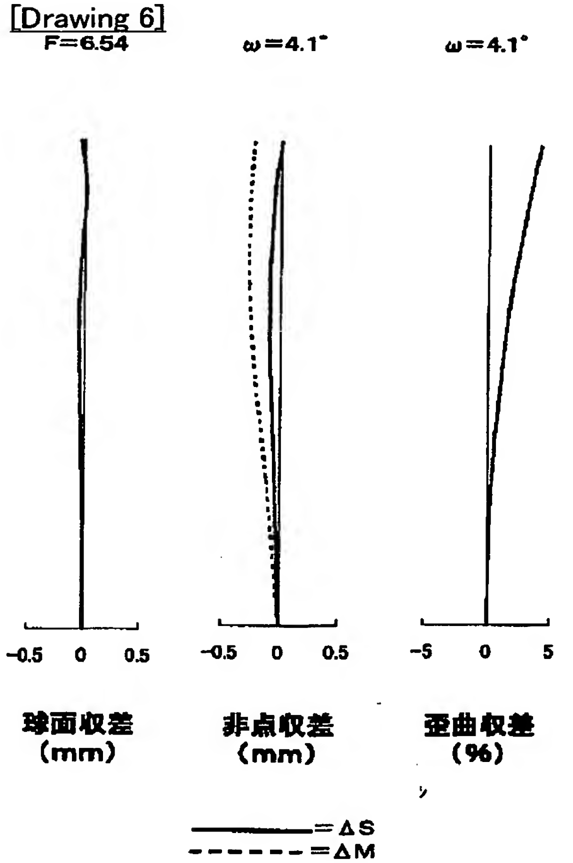
[Drawing 4]



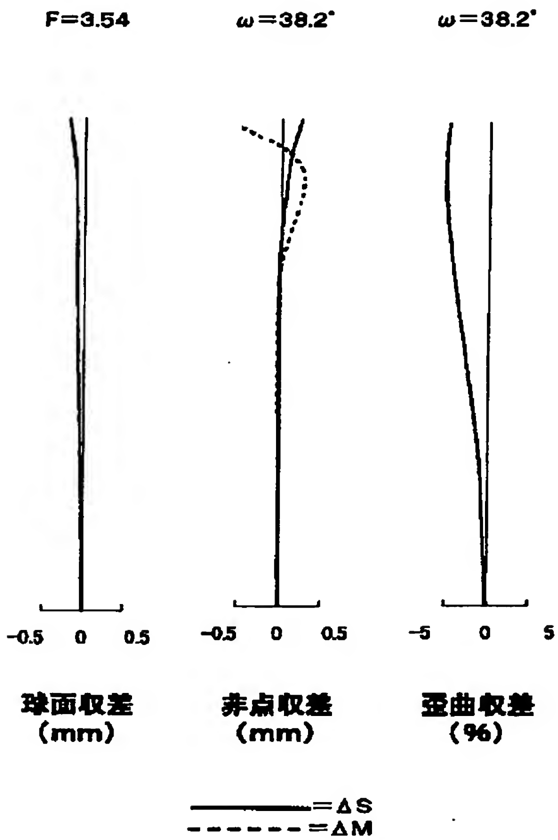
[Drawing 5]



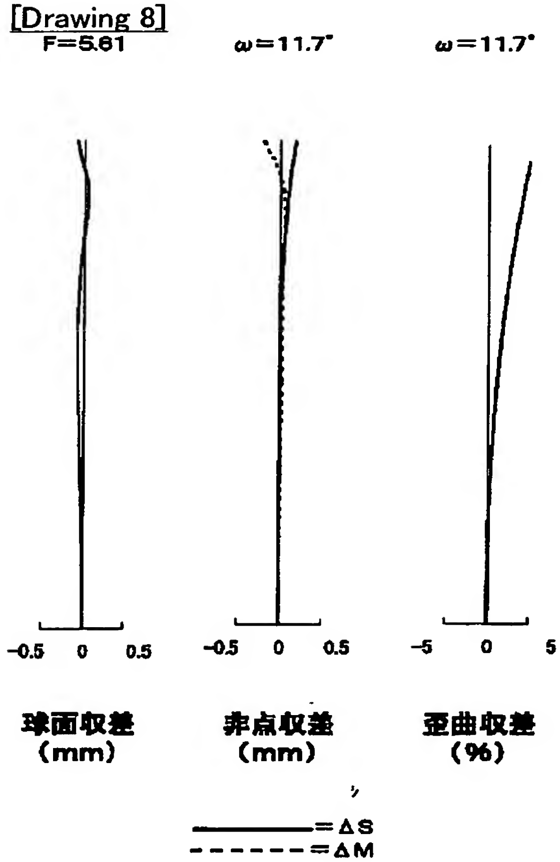
[Drawing 6]



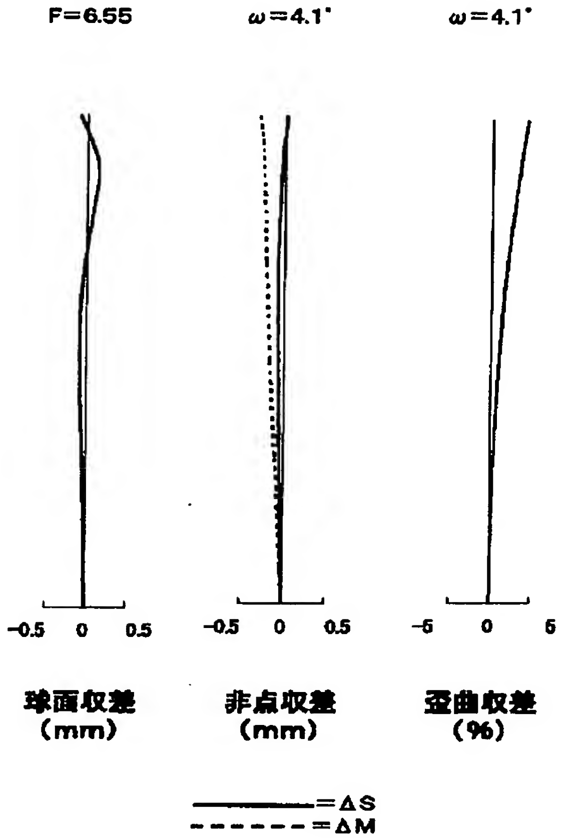
[Drawing 7]



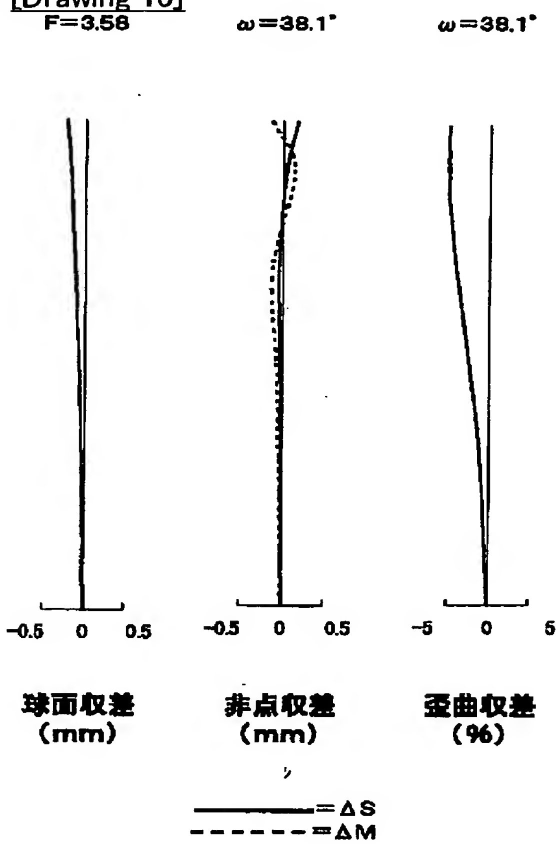
[Drawing 8]



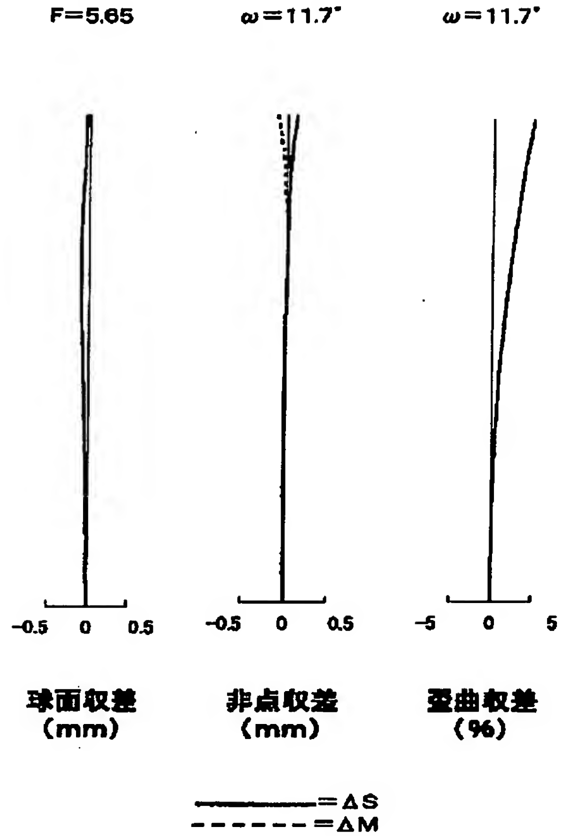
[Drawing 9]



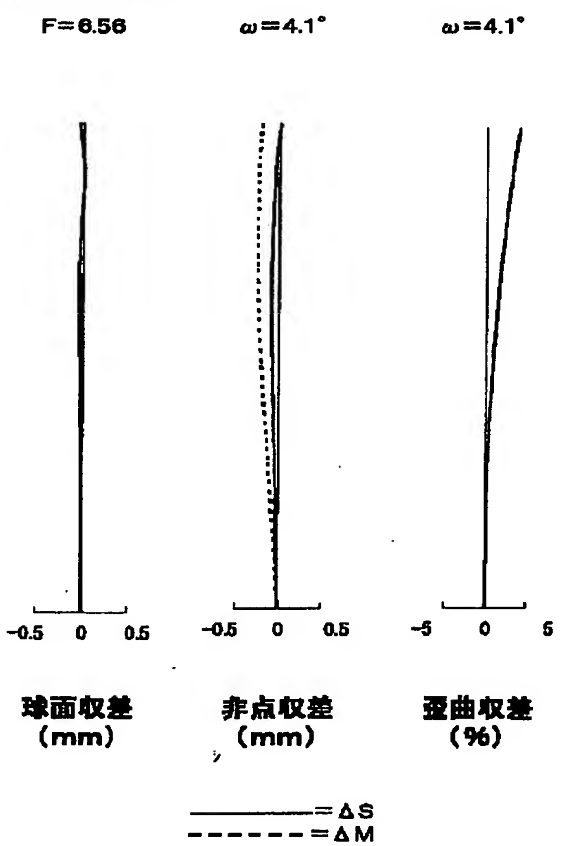
[Drawing 10]



[Drawing 11]


F=5.65
ω=11.7°
ω=11.7°
-0.5 0 0.5
-0.5 0 0.5
-5 0 5
球面収差 (mm)
非点収差 (mm)
歪曲収差 (%)
=ΔS
=ΔM

[Drawing 12]


F=6.56
ω=4.1°
ω=4.1°
-0.5 0 0.5
-0.5 0 0.5
-5 0 5
球面収差 (mm)
非点収差 (mm)
歪曲収差 (%)
=ΔS
=ΔM

[Translation done.]